ESA-129 Final Public Report

Introduction
The DOW Chemical Company's Freeport site consists of several production units. Although it is extremely widespread, the site steam distribution infrastructure is integrated across all the production units. There is a very high level of metering and accountability of utilities across the DOW Freeport site which allows DOW personnel to understand, track and trend usage within different production units.

The DOW Chemical Company's Allyl Chloride plant in Freeport, TX was the focus of a 3-day steam system Energy Savings Assessment (ESA). The plant has a boiler and additional steam is imported from the site headers. Excess condensate is exported back to the site.

Objectives of ESA
The main objectives of the ESA were as follows:

- Understand and identify steam system energy savings opportunities for the overall plant and focus on a couple of areas to estimate the magnitude of potential improvement opportunities
- Use the DOE Steam tools such as the Steam System Scoping Tool (SSST), Steam System Assessment Tool (SSAT) and the 3E Plus insulation software to model the steam system at the plant
- Assist the plant team to familiarize and have the ability to use all of the above mentioned tools to identify energy efficiency improvement opportunities at the plant and quantify the potential energy savings associated with the steam system

Focus of Assessment
The boiler and steam system at the Allyl Chloride plant were the main focus of the Steam ESA. Although no other plants participated in this Steam ESA, there are several production units at the DOW Freeport site that use steam and all facets of this ESA can be shared throughout the technical community. DOW personnel will be able to use SSST, SSAT and 3EPlus, on an as needed basis, to evaluate other production units.

Approach for ESA
The ESA core plant team included personnel with varied responsibilities for the Allyl Chloride plant that includes Best Practices, Engineering, Operations, Maintenance, Reliability and Control. The ESA core team completed the Steam System Scoping Tool (SSST) on the steam system and sent it to the ESA expert prior to the start of the ESA. The steam system at the plant consists of one steam generating boiler and the plant purchases site steam at different pressure levels. The plant team first decided to focus on the overall steam (energy) balance of the plant. After having a fair understanding of the overall plant, the team focused on a couple of areas to implement the SSAT and identify energy saving opportunities. The plant assessment lead downloaded the Steam System Assessment Tool (SSAT) from the DOE website to quantify potential steam system efficiency opportunities for natural gas and steam energy savings. Steam system models were used to study the impact of potential improvement opportunities at the plant. Data was collected from the plant PI system during the ESA. The quantified potential savings opportunities are reported in the sections below.

General Observations of Potential Opportunities
There is a significant level of industry best practices in place at the Allyl Chloride plant, which is clearly reflected in the above average score that the plant received on the SSST.

The steam system at the plant is relatively simple but integrated with the process. The plant has a boiler that produces steam. The plant also purchases steam from the site header system which supplements the steam production of the plant boiler.

Based on the Steam ESA, steam savings opportunities exist in different areas. These were evaluated using the SSAT models. Site-wide incremental costs of electricity, natural gas and steam were used to calculate the energy cost savings opportunities for the plant. It has to be noted that due to the complexity of the Freeport site steam balance and the constraints of proximity, headers, etc., some of these improvement opportunities may not be economically justifiable. Additional due diligence and engineering analysis will be needed to finalize the opportunities.

1. **Optimize flue gas oxygen in the boiler combustion process (Near term)**
   This opportunity aims to optimize the amount of flue gas oxygen or excess air supplied to the boiler using an oxygen trim control system. Another plant at the DOW Freeport site has already implemented this opportunity. Based on current operating oxygen levels, an increase in boiler energy efficiency of 2.5% may be achievable.

2. **Heat recovery from boiler flue gas (Long term)**

The flue gas exit temperature from the boiler could be reduced by installing an economizer and preheat the make-up (condensate) or the boiler feedwater. Preheating of combustion air could also be considered.

3. **Change boiler blowdown rate (Near term)**

Currently, boiler surface blowdown is manually controlled. Plant personnel can reduce it with small step changes ensuring acceptable water chemistry at all times. Alternatively, an automatic blowdown controller can be installed for this service.

4. **Install blowdown flash to low pressure steam (Medium term)**

The boiler surface blowdown is sent to the drain. Ideally, this blowdown can be flashed to recover low pressure steam which can be used for the deaerator. This will reduce the overall steam demand of the plant. Alternatively, a feedwater heat recovery exchanger can be installed to recover the thermal energy from the blowdown for a higher efficiency.

5. **Return condensate with highest thermal energy (Medium term)**

The plant flashes condensate to ambient and condenses the vapors. A better solution would be to return all the condensate directly to the deaerator. This would result in returning condensate with the highest thermal energy and the flashing would provide the steam for the deaerator operation. Any additional steam needed by the deaerator can be obtained from the steam header.

6. **Clean fouled heat exchanger (Medium term)**

Plant personnel have been monitoring and trending performance of key heat recovery exchangers and have identified this opportunity. The real energy savings due to cleaning is difficult to evaluate, so plant personnel used a simplified approach to estimate these savings based on the difference in steam consumption between clean and fouled operation. It has to be noted that even this simple calculation wouldn't have been possible if the plant did not have a monitoring, trending and historian data collection system.

7. **Modify Operation of Backpressure Steam Turbines - HP to LP (Medium term)**

There are several different alternatives for the operation of back-pressure steam turbines. All the identified opportunities were investigated using the SSAT during the ESA and are listed below.

<u>Option 1: Use of higher pressure steam</u>

Steam is available at higher pressure from a neighboring production unit. Before supplying this steam to the Allyl Chloride plant, they reduce it down using a pressure letdown station. Since steam is used to drive back pressure turbines, it would be more efficient to use the higher pressure steam directly in the turbines. This would reduce the steam rate (lb/hp-hr) of the steam turbines.

<u>Option 2: Improve back-pressure steam turbine efficiency</u>

Based on discussions with Operations and Maintenance, it was found that the steam turbines maybe due for a turnaround and overhaul. This could improve the operating turbine isentropic efficiency. Actual operating efficiency was compared with manufacturers design data to estimate the potential energy savings opportunities.

<u>Option 3: Converting back pressure to condensing steam turbines</u>

This opportunity evaluates the impact of converting (replacing) the back pressure turbines with condensing turbines. This would significantly reduce the steam rate (lb/hp-hr) of the steam turbines.

<u>Option 4: Replace steam turbines with electric motors</u>

Energy Systems personnel have evaluated this opportunity at several occasions before and haven't found it to be feasible due to site constraints and economic impact.

8. **Other opportunities & BestPractices**

<u>Insulation upgrades (Near term)</u>

The plant has certain areas where there might be insufficient or missing insulation.

<u>Improve compressor efficiency (Medium term)</u>

Based on manufacturers' data, the isentropic efficiency of each compressor was compared to the current operating efficiency. It was found that efficiency was below design. Improvements to the system could lower steam demand by the turbines.

Monitor and trend equipment efficiencies (Best Practice)

There is a significant amount of instrumentation available in the Allyl Chloride plant. Plant personnel trend and record this information as well as use it real-time to make operating decisions. One best practice that can be adopted by the plant is to calculate "efficiency" metrics of the individual equipment and use it as a tool to effectively implement a "Predictive and Preventative Maintenance" program for the plant.

Management Support and Comments

From a corporate standpoint, the DOW Chemical Company has set a target of 25% energy intensity reduction in the next 10 years. At the Freeport site, there exists a Site Optimization and Integration team that is defining and helping to meet the energy reduction goals for the individual plants. Technical experts work closely with the operations to implement best practices and optimize the operation of the Allyl Chloride plant. The plant management has provided full support to the ESA Team to capture any and every economically justifiable opportunity. This commitment and support was clearly evident at the Steam ESA meetings. Plant personnel spent three days working with the ESA Specialist and will continue to work on identifying projects site-wide thereby re-affirming their goals, strategy and energy saving opportunities.

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The definitions for Near Term, Medium Term and Long Term opportunities are as follows:

- Near term opportunities would include actions that could be taken as improvements in operating practices, maintenance of equipment or relatively low cost actions or equipment purchases.
- Medium term opportunities would require purchase of additional equipment and/or changes in the system such as addition of recuperative air preheaters and use of energy to substitute current practices of steam use etc. It would be necessary to carryout further engineering and return on investment analysis.
- Long term opportunities would require testing of new technology and confirmation of performance of these technologies under the plant operating conditions with economic justification to meet the corporate investment criteria.